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$T^3B$: Test Microcomputer Architectural Design

US Army Corps of Engineers

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TECHNOLOGY TRANSFER TEST BED PROGRAM

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# Corps of Engineers National Automation Team (CENAT) Technology Transfer Test Bed ($T^3B$) Demonstration of the Design 4D Program



by
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This report documents the FY88 Technology Transfer Test Bed ($T^3B$) demonstration of the Design 4D Program. The program was developed by USACERL as an architectural modeler that uses three-dimensional geometry and a seamless database manager. The overall objective of this research was to test microcomputer-based architectural design tools for applicability to the U.S. Army Corps of Engineers Military Design program.

Among the features in the Design 4D program is the ability to easily sketch in a three-dimensional (3D) perspective view, as well as an equivalent two-dimensional (2D) view. A set of 3D layout tools is available that works in the principal three orthogonal planes, as well as any user defined plane. Design 4D allows the user to easily manipulate both the 2D and 3D views using 3D rotates, zooms, and pans. Design 4D's modeling techniques allow the user to evaluate the design at any early stage.

Architects at the Corps of Engineers Huntsville Division, Savannah District, Sacramento District, and Norfolk District used Design 4D as their workload allowed. They indicated that Design 4D is easy to use, helps them analyze early design alternatives, and helps them visualize design alternatives. Based on their responses, the menu structure will be reorganized, digitizer input will be accepted, and the user will be able to assign the button functions on the mouse input device. Based on interest and demand, the number of test sites for Design 4D will be increased.

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# TECHNOLOGY TRANSFER TEST BED PROGRAM

## FINDINGS AND RECOMMENDATIONS OF TEST/DEMONSTRATION

WORK UNIT NO./TITLE OF TEST: FAD No. 89-080004,
Test Microcomputer Architectural Design

PERFORMING LABORATORY: USACERL PRODUCT/SYSTEM: Design 4D Program

PERFORMING TEST SITES: U.S. Army Corps of Engineers, Huntsville Division, Savannah District, Sacramento District, and Norfolk District

DESCRIPTION/OBJECTIVE OF TEST/DEMONSTRATION:

Architects from Huntsville Division, Savannah District, Sacramento District, and Norfolk District tested the Design 4D Program, an architectural modeler. The objective was to evaluate Design 4D's ease of use, ability to help the user analyze early design alternatives, and ability to share data with other design tools.

RESULTS OF TEST/DEMONSTRATION:

Training for the Design 4D Program was conducted at USACERL. Although nearly half of the test subjects had difficulty with the prompts, their understanding of the program improved after experimenting with the commands. After training, most felt that they could use Design 4D productively, but could not teach it to others. Architects used the Design 4D program at the test sites as their workload allowed. They believe that the Design 4D Program offers three main advantages. First, it addresses the conceptual design phase in the architectural process. Second, it is helpful in three-dimensional visualization of design alternatives. Third, it is an easy sketching tool. Thus, Design 4D meets the requirements of being easy to use, and helping the user analyze early design alternatives and visualize design alternatives.

RECOMMENDATIONS FOR PRODUCT/SYSTEM:

Based on comments from the users, the menu structure should be reorganized. A network-like approach should be implemented to shorten the learning curve. Architects would also prefer that the button functions on the mouse input device be consistent with current CAD systems. This change is recommended. Future system updates should allow digitizer input. It is also recommended that the number of test sites be increased. Although some of the unique features of Design 4D will soon be incorporated into commercial CAD software, Design 4D will still provide a basis for research and development.

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This report documents the FY88 Technology Transfer Test Bed ($T^3B$) demonstration of the Design 4D Program. The program was developed by USACERL as an architectural modeler that uses three-dimensional geometry and a seamless database manager. The overall objective of this research was to test microcomputer-based architectural design tools for applicability to the U.S. Army Corps of Engineers Military Design program.

Among the features in the Design 4D program is the ability to easily sketch in a three-dimensional (3D) perspective view, as well as an equivalent two-dimensional (2D) view. A set of 3D layout tools is available that works in the principal three orthogonal planes, as well as any user defined plane. Design 4D allows the user to easily manipulate both the 2D and 3D views using 3D rotates, zooms, and pans. Design 4D's modeling techniques allow the user to evaluate the design at any early stage.

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# FOREWORD

This investigation was performed for the Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers (HQUSACE), as a project in the Technology Transfer Test Bed Program ($T^3B$) under the Corps of Engineers National Automation Team (CENAT). The Work Unit was titled "Test Microcomputer Architectural Design." The HQUSACE Technical Monitor was Mr. Don Dressler, CEMP-ED.

This research was performed by the Design Systems Team, Facilities Systems Division (FS), U.S. Army Construction Engineering Research Laboratory (USACERL). In addition to the authors, USACERL personnel directly involved in the study were Kenneth H. Crawford, Jeffery S. Heckel, and Eric D. Griffith of the Design Systems Team. Mr. L. Michael Golish is the Team Leader of the Design Systems Team and Dr. Michael O'Connor is Chief of USACERL-FS. The Technical Editor was Gloria J. Wienke, USACERL Information Management Office.

Research and development of the Design 4D program was done for HQUSACE under Project 4A162731AT41 "Architectural Design System", Work Unit A08, whose Technical Monitor was Mr. Dan Duncan CEEC-EA. The principal developers were Kenneth H. Crawford, Laura S. Bond-Harris, Beth Alain Symonds, Jeffery S. Heckel, and Eric D. Griffith.

COL Carl O. Magnell is Commander and Director of USACERL, and Dr. L. R. Shaffer is Technical Director.

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# 1 INTRODUCTION

## Background

A common complaint by users of computer-aided drafting (CAD) systems is that the software is often marketed as a design tool, but it does not significantly help in the early schematic concept design process. This process is a decision-making activity that has additional unmet needs. Current CAD software's greatest use is in developing contract drawings, which is a documentation activity.

In an effort to address the needs of concept design, the U.S. Army Construction Engineering Research Laboratory (USACERL) evaluated and tested several commercially available architectural modelers. Solid Vision was found to be the most powerful microcomputer-based modeler available. In Fiscal Year 1987 (FY 87), Solid Vision was tested at U.S. Army Corps of Engineers (USACE) Offices at Savannah, GA, and Sacramento, CA, and was rejected because of a clumsy user interface. Since the test, Solid Vision has been withdrawn from the U.S. commercial market for this very reason.

During this same period, USACERL was developing Design 4D, which became available for testing in FY 88. Design 4D is an architectural modeler that uses three-dimensional (3D) geometry and a seamless database manager. To be a decision-making tool, a modeler needs several capabilities that must be successfully merged. These capabilities were the main focus of the Design 4D development team. First, the modeler must be a flexible 3D sketching tool. A functional test to verify this capability is called the "yellow flimsy" test. If the tool does not successfully replace sketch paper as a design medium, it will not be used successfully for decision making.

Given the capability to easily lay out a design directly in the computer, the system must also have strong analytical capabilities. This must be reflected in the way graphic and nongraphic information is stored and integrated. The system must combine the "object" orientation of a solid modeler with the flexible information manipulation capabilities of a relational database manager. Integration of the object database and geometric engine permits object classes to be created from the existing geometry of a schematic drawing (free sketching). Conversely, object class descriptions can be used to automatically generate schematic drawings. The database must also provide an easy link to various analyses, some that have not yet been defined.

Design 4D's user interface provides several new capabilities for the architect. First, sketching may be done entirely in perspective if the designer chooses, or by alternating between 2D and 3D as desired. The 3D interface is not limited to extrusions of 2D shapes and lines. A varied set of 3D layout tools that works equally well in any drawing plane is also provided.

Several aids help the designer work in perspective without becoming "lost in space," which frequently occurs in other design systems. The primary display technique for locating oneself in 3D space is a background perspective grid. Design 4D employs a "planar" approach to visually aid 3D drawing. A current drawing plane is displayed within the 3D perspective grid, located along either the X, Y, or Z axes. The current drawing plane can also be user-defined and located at any angle in the perspective space (Figure 1). The user-defined plane option allows for a sloped drawing plane, which simplifies the generation of roofs or other slanted entities. One of several available cursors residing on the current drawing plane gives the user a variety of sketching techniques.

The current drawing plane can be dynamically moved along any principal axis or user defined plane. A graphical "tab" allows the drawing plane to move easily through space, jumping to the next escending or descending line end point. When a point is found, it is highlighted with a tick mark, as are all other points on that particular plane.

Design 4D provides color fill as a realtime aid to the designer and eliminates the need to have a separate paint/rendering program. As an object is generated, the facets (polygons) can be colored and shaded. Once generated, the object can be rotated and quickly repainted in 3D. The repaint speed helps the designer to visualize tne model during design development, eliminating the wait normally associated with rendering programs.

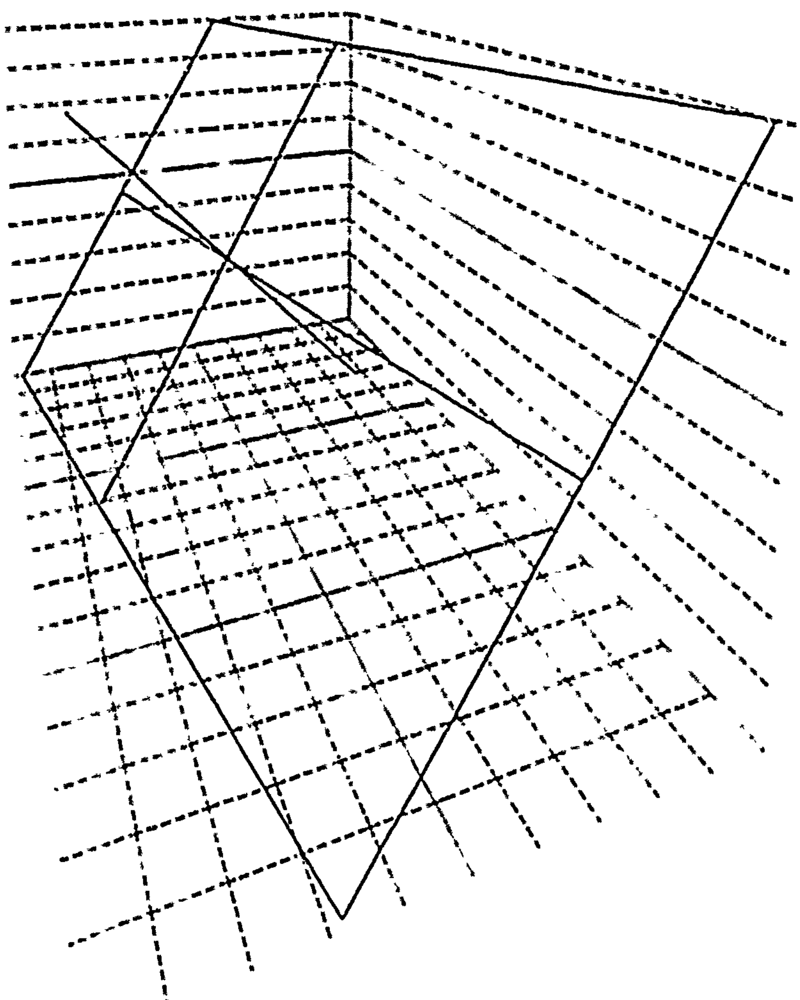

Figure 1. Background perspective grid with user-defined drawing plane.

## Objective

The objective of this work was to conduct formal field tests of Design 4D as part of the Technology Transfer Test Bed Program ($T^3B$).

## Approach

Design 4D was selected for testing at three districts and one division that have large military programs. Two of the test sites had existing turnkey CAD (Huntsville, AL, and Savannah, GA) and two did not (Norfolk, VA, and Sacramento, CA). The district architects used the program on projects as the workload allowed. The modeler was evaluated on its ease of use, its ability to help the user analyze early design alternatives, and its ability to share data with other tools. After initial testing, Design 4D will be revised and additional test sites will be selected.

## Mode of Technology Transfer

USACERL plans to deliver the Design 4D system, including online help and a user's manual, to USACE districts and divisions. The technology is also being transferred through a Cooperative Research and Development Agreement signed in FY 88 with Isicad, Inc. of Anaheim, CA. They are incorporating a subset of Design 4D's 3D planar approach and dynamic interface in their current microcomputer-based CAD system, Cadvance.

## 2 DETAILS OF THE TEST

### Huntsville Division

Because Huntsville is the lead division for initial testing of CAD in the Corps of Engineers, they have extensive experience with the Intergraph workstation architectural software package and Microstation, Intergraph's microprocessor-based package. In addition, they have some experience with Autocad and Autocad AEC from Autodesk. The test subjects were familiar with both mouse and digitizer input devices.

### Norfolk District

Norfolk has recently started to automate its architectural process and its designers are currently using Autocad by Autodesk on microcomputers. Before the test, the test subjects were only familiar with digitizer input devices.

### Sacramento District

Sacramento has a varied background in CAD systems. One design section has been recently reorganized into a CAD section based on Intergraph workstation software and Microstation. The test subjects had used an array of packages, including Autocad, Solid Vision, and Megacad. The test subjects were experienced with both mouse and digitizer input devices.

### Savannah District

Savannah has used Intergraph workstation software packages extensively. The te t subjects were primarily familiar with digitizer input devices.

### Equipment

All the test sites were provided with 386-class computers with math coprocessors. The microcomputers were equipped with graphics boards and monitors compatible with the Professional Graphics standard. A three-button mouse was provided as an input device. The operating system was DOS. Both the previously tested $T^3B$ software and Design 4D operate on this environment. This was also the developmental environment for Design 4D at USACERL.

### Testing Process

The test sites received management plans for the test of Design 4D. Funds were sent to test sites to compensate for travel, training, and labor expended during the testing process. The test subjects/architects met for training at USACERL. After training, a written survey was completed. The survey provided information regarding subjects' CAD experience, attitudes, and training experience with Design 4D. The architects left with current versions of Design 4D to test at their site. All test sites have received updated versions since the training. The architects used Design 4D when their current workload allowed. After a set time, they completed field test evaluation reports. The test sites will continue to receive updates of Design 4D software and will perform a final evaluation before the end of FY 89.

## 3 TEST DISTRICT TRAINING

### Training Process

Two architects from each of the four test sites came to USACERL for training: Sacramento on July 12 and 13, 1988, Huntsville and Norfolk on July 19 and 20, 1988, and Savannah on August 10 and 11, 1988. During training, the test subjects received a draft version of Design 4D documentation. The user's manual included information about the initial startup phase, a quick tutorial, a partial command reference, keyboard function tables, and forms for reporting suggestions and errors. During training, USACERL staff provided the architects with technical assistance. After training, the architects filled out surveys consisting of multiple choice and short answer questions. Their answers are summarized below. The Appendix contains a more complete summary.

### Post Training Survey

*Experience with Computers*

All the architects had used computers for drafting. A little over half had used computers for design. The majority had been exposed to Autocad and Intergraph CAD systems; some of them had been exposed to other systems. While they were all familiar with both mouse and digitizer input devices, they showed a slight preference for digitizer input devices.

*Attitudes Toward Computers*

The architects had positive attitudes toward computers. They felt comfortable with computer use in general, as well as computer use to assist the architectural process. The majority preferred microcomputer-based CAD systems to mainframe systems. While slightly more than half of the test subjects had used a computer in the design process, three quarters believed computers could be useful in design.

*Response to Design 4D*

At the start of the test, the subjects had positive attitudes toward the program. During training, nearly half of the subjects had difficulty with the prompts, but they all indicated that experimenting with the commands improved their understanding of the program. Most felt they needed the manual as well as online help.

Design 4D offers a variety of input methods. The architects felt that while both keyboard input during drawing and command line input were appropriate, they prefer more mouse input.

At the end of the training, most felt they could use Design 4D productively without additional training. Still, they did not feel they could teach Design 4D to others. They also felt that prior experience with computers in general and drawing and/or drafting are prerequisites for using Design 4D. Their original positive attitudes were maintained, as they all indicated that they liked Design 4D after training.

**Post Training Results**

As a result of surveys, observations, and suggestions made during training, USACERL established development areas, priorities, and future research thrusts. A month after training, updated versions of Design 4D and draft documentation were distributed to all sites. The update modifications are listed below.

- Error corrections
- New interface to manipulate blocks of geometric information
- Improved command line input
- Improved modeling interface
- Mouse input bias allowed
- Updated documentation.

## 4 TEST SITE EVALUATION

After training, all test sites received an updated version of Design 4D. The architects were asked to use Design 4D as their current workload allowed. After a period of time, they completed field test evaluation reports that consisted of open-ended short answer questions. Their responses are summarized and evaluated below.

### System Preference

The architects expressed strong support for the use of microprocessor-based CAD and indicated that when a project involves only one person or discipline, the appropriate platform is the micro-based computer. Various arguments for micro-based systems include cost, quicker response, and ease of use. Some of the test subjects felt that microcomputers were best suited for concept design, while others felt they were the appropriate vehicle for all architectural design.

The architects felt that minicomputer and mainframe CAD is still needed for certain cases. A larger system works best when a project database is large or shared, as in a team project. There was a consensus that when multiple disciplines are working on a single project, a mainframe/minicomputer environment is the correct one.

### Design 4D's Performance

The architects felt that Design 4D offered three advantages. First, the majority felt it addressed the conceptual design phase in the architectural process. Second, there was a consensus that Design 4D was helpful in 3D visualization of design alternatives. Third, Design 4D proved to be an easy sketching tool.

All of the architects felt that Design 4D met their concept design needs. One of the comments was "this is where [Design] 4D pays off, and should remain [a] preconcept/quick alternative to sketch phase." The test sites performed massing and volume studies using the program. One site modeled a design project that had been manually drafted. The design was altered as a result of the Design 4D model. These findings suggest that Design 4D met the initial test criteria of helping the user analyze early design alternatives.

One of Design 4D's unique features is the ease of generating and changing 3D views. This allows the architect to visualize the design at an early stage. The architects at the test sites found that dynamic rotations, panning, and zooming of the 3D perspective grids, modeling, light source shading, and hidden line removal were useful 3D visualization tools. The users felt that these capabilities made Design 4D better than the available alternatives. In one project, Design 4D's 3D modeling capabilities were used to visualize the design's complex sloped roofs. In the future, they intend to use Design 4D to study the volumetric relationships of building wings. The test subjects are using Design 4D's 3D visualization capabilities to analyze their design alternatives.

The "planar" approach discussed in Chapter 1 was well received. Test subjects were able to "immediately understand where [they were] in space." They felt it was easy to generate 3D forms to produce quick models. This suggests that Design 4D met the test criteria for ease of use.

Most of the test subjects felt that after a short discovery period, the menu structure was easy to understand. The Quickdraw menu, an icon-driven menu, was very popular and the architects found it easiest to use. Currently the menus are organized in a hierarchical fashion that requires the user to become familiar with the entire tree structure. As a result of the testing, USACERL is reorganizing the menu structure. A network-like approach is being implemented to shorten the learning curve. In light of the Quickdraw menu's appeal, the reorganized system will feature this icon-driven menu as the primary menu, with the submenus always accessible. These changes will be included in the next update to be delivered to the test sites in November 1988.

**Time Saved**

USACERL expects that any time savings created by design software packages will be reinvested in the production and evaluation of design alternatives. This hypothesis is supported by the test findings. The architects commented that Design 4D improved design quality by offering early visualization of design alternatives. Of those that used Design 4D in the design process, some found that it reduced their design time, while others did not. Specifically, time was reduced in the sketching and modeling processes. One architect commented that, "it was perfectly satisfactory for converting a 2D drawn image into a 3D model with endless viewing possibilities."

**Design 4D and Existing CAD Capabilities**

Test subjects with extensive 3D system exposure, and those with less experience, felt that Design 4D supplemented their existing CAD capabilities. It brought 3D visualization into the design process at an earlier point. One of the test subjects had 3D capability available, but did not use it, although this subject embraced Design 4D's 3D interface. It is interesting that some architects felt Design 4D enhanced their understanding of other CAD software. This suggests that Design 4D's interface promotes conceptual understanding, which is transferrable.

## 5 LESSONS LEARNED - USER INTERFACE ISSUES

During the testing of Design 4D, USACERL was particularly interested in the following interface issues: being able to locate oneself in 3D space, having a flexible approach that replaces yellow tracing paper, and determining appropriate input methods.

From the users' responses, it is evident that they were able to locate themselves in 3D space. To provide flexibility, Design 4D emphasized easy sketching techniques and offered various option selection techniques. The subjects found it easy to sketch (as discussed in Chapter 4). In addition, the users appreciated the option selection methods, including menu choices and typed commands. They requested that the prototype methods be expanded. While the architects liked input by mouse and keyboard, they wanted the addition of digitizer input. An unanticipated user response was a bias on the mouse button functions. The architects wanted the button functions to be consistent with their current CAD systems. In response, Design 4D will allow the user to assign mouse button functions and digitizer input in future updates.

## 6 TEST SUPPORT

During the test period, USACERL supported the test sites by providing telephone assistance, hands-on training, and suggestion and error forms. Test feedback has been incorporated into Design 4D updates and the test sites received an updated version. USACERL will continue to collect test site data as input for future versions of Design 4D.

As a result of the testing, future research issues have been identified. The majority of the architects felt a need for a programmatic functional layout tool. This tool should have the ability to go "from functional relationships to bubble diagrams to square footage space analysis to 3D massing studies." Before Design 4D's development, a prototype system, Charrette, was developed at USACERL that dynamically layed out functional areas. This system was tested at the Sacramento District Office and at the School of Architecture at the University of Illinois, Urbana, IL. Unfortunately, it was limited to a 2D interface, and was on a hardware platform not readily accessible to Corps' offices. While evaluating Design 4D, the architects at Sacramento stated, "A Charrette interface with space analysis; bubble diagraming and 'square footage stretching' would be the most significant improvement to 4D, one that would set it apart from other modeling software." This layout tool must be consistent with Design 4D's current easy interface.

The majority of the test subjects were interested in future development of interfaces to drafting software packages. The subjects were asked if they wanted development of interface to existing tools/other disciplines (e.g., CACES [cost], BLAST [energy]). There was very little interest in this type of interface. The subjects' feelings were expressed as "keep [Design] 4D at the preconcept sketch phase application."

In the interest of creating a rapid prototype when Design 4D was developed, USACERL depended on the Professional Graphics Adapter Standard (PGA). With recent technological developments, the Video Graphics Array (VGA) has become the low cost graphic standard of choice for 386-class machines. Future versions of Design 4D will be able to run on VGA hardware. Since a high resolution graphics standard has not yet emerged, researchers have no obvious target platform that could take advantage of developing capablities.

# 7 CONCLUSIONS AND RECOMMENDATIONS

Overall, the architects at the four test sites were supportive of Design 4D and have used it beyond the test period. They indicated that Design 4D is easy to use, helps them analyze early design alternatives, and helps them visualize design alternatives. However, they identified several changes and made suggestions for future development issues to enhance Design 4D. Based on their comments, it is recommended that the menu structure be changed to a network-like approach. Future system updates should allow digitizer input and allow the user to assign the button functions on the mouse input device.

USACERL has received requests to increase the number of test sites. The Corps-wide Engineers' Architectural Applications Task Group (AATG) has expressed an interest in being included in the test. With the expertise this group represents, it is a natural candidate for a test site. It is recommended that this group be included in testing the revised Design 4D program.

Some of the unique features of Design 4D will soon be incorporated in commercial CAD software through a Cooperative Research and Development Agreement that has been signed with private industry. Design 4D will still provide a basis for USACERL research and development.

Future research in computer aided architectural design software can benefit from the lessons learned during the testing of Design 4D.

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## APPENDIX: POST TRAINING SURVEY RESPONSES

### Multiple Choice Questions

1. I feel generally competent with the Design 4D concepts covered in the last few days.

AGREE - 86% DISAGREE - 14%

2. I like Design 4D.

AGREE - 100% DISAGREE - 0%

3. Having previous experiences in drawing and/or drafting is necessary before attempting Design 4D.

AGREE - 100% DISAGREE - 0%

4. A manual covering Design 4D is necessary.

AGREE - 100% DISAGREE - 0%

5. In order to use Design 4D productively, I need more training.

AGREE - 28% DISAGREE - 72%

6. The computer won't allow me to express my design ideas as well as I can manually.

AGREE - 0% DISAGREE - 100%

7. I believe that I could use Design 4D in my work projects.

AGREE - 100% DISAGREE - 0%

8. I had trouble following the prompts.

AGREE - 44% DISAGREE - 56%

9. I feel capable of teaching Design 4D to others.

AGREE - 28% DISAGREE - 72%

10. I like working with computers.

AGREE - 100% DISAGREE - 0%

11. Trying the Design 4D commands helped me learn.

AGREE - 100% DISAGREE - 0%

12. Design 4D was too difficult for me.

AGREE - 14% DISAGREE - 86%

13. Computers are not helpful in the design process.

AGREE - 28% DISAGREE - 72%

14. I needed more feedback from the computer program (more prompts, more error messages).

AGREE - 44% DISAGREE - 56%

15. The computer helps me consider different possibilities in my design.

AGREE - 100% DISAGREE - 0%

16. Having previous computer experiences is necessary before using Design 4D.

AGREE - 86% DISAGREE - 0%

17. I expected to like Design 4D.

AGREE - 100% DISAGREE - 0%

18. I don't understand much about the concepts of Design 4D.

AGREE - 14% DISAGREE - 86%

19. I usually knew when I did things wrong in Design 4D.

AGREE - 72% DISAGREE - 28%

20. I prefer micro CAD to mainframe CAD.

AGREE - 70% DISAGREE - 14%

21. I would prefer more mouse input.

MORE - 56% ABOUT RIGHT -14% LESS - 30%

22. I would prefer more keyboard input.

MORE - 0% ABOUT RIGHT -72% LESS - 28%

23. I prefer command line input to selecting options from a menu.

MORE - 14% ABOUT RIGHT -58% LESS - 28%

**Short Answer**

1. Are you using a computer for design?

YES - 56% NO - 44%

If so, what system or software?

| | |
|---|---|
| Autocad | 100% |
| Intergraph | 75% |
| Megacad | 25% |

2. Are you using a computer for drafting?

YES - 100%     NO - 0%

If so, what system or software?

| | |
|---|---|
| Autocad | 72% |
| Intergraph | 72% |

3. What CAD systems have you used?

| | |
|---|---|
| Autocad | 84% |
| Intergraph | 72% |
| Megacad | 14% |
| Solid Vision | 14% |
| Arch | 14% |

4. What input devices have you used?

| | |
|---|---|
| Mouse | 100% |
| Digitizer | 100% |

Which do you prefer?

| | |
|---|---|
| Mouse | 44% |
| Digitizer | 56% |

5. To what extent did you use command line input?

| | |
|---|---|
| Range of responses: | 7.5% - 50% |
| Average response: | 24% |
| Median response: | 25% |

6. To what extent did you use the keyboard during drawing mode? (i.e., X,Y,Z,O,D, & C keys)

| | |
|---|---|
| Range of responses: | 5% - 50% |
| Average response: | 24% |
| Median response: | 25% |

7. What did you think about the Design 4D screen setup? (Menu, coordinate display, prompts, drawing areas, etc.)

Proposed layout better
Command line change
More prompts

8. Which options did you use the most?

| | |
|---|---|
| In Drawing mode: | |
| Extrude | 42% |
| Forms | 28% |
| In Display mode: | |
| Fit Grids | 14% |
| Four Viewports | 14% |
| Grid Space | 14% |
| Light Source | 14% |
| Pan/Zoom | 14% |
| Rotate | 14% |

9. Which options were your favorite?

| | |
|---|---|
| In Drawing mode: | |
| Rotate | 56% |
| Forms | 28% |
| Modeling | 28% |
| Colors | 14% |
| Extrude | 14% |
| Modeling | 14% |
| In Display mode: | |
| Four Viewports | 14% |
| Rotate | 14% |
| Fit Grids/Lines | 14% |
| Light Source | 14% |

10. Which menu did you seem to use the most?

| | |
|---|---|
| Quick Draw | 72% |
| Drawing | 14% |
| Viewing | 14% |

**Subject Information**

1. Job Description: Architects (8) 100%
2. GS Grade: Range GS 07 - GS 14

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